36th International Electric Vehicle Symposium and Exhibition (EVS36)
Sacramento, California, USA, June 11-14, 2023

Process Overview and Unique Considerations For Deploying Commercial Fleet Infrastructure for a School Bus Fleet

Kevin L. Matthews

Head of Electrification, First Student,600 Vine Street, Suite 1400, Cincinnati OH 45202,
kevin.matthews@firstgroup.com

Executive Summary

First Student, the largest provider of student transportation across North America, has made a conscious commitment to electrify our 46,000+ fleet of school buses as rapidly as possible. Through this paper, First Student would like to share with the readers the process and insights gained in deploying infrastructure to support electrification of its school bus fleet. These insights have been distilled from our operational experience and validated through the successful implementation of the world's largest, active electric school bus fleet deployment in the Quebec province of Canada where more than 230 electric buses are currently transporting students to and from school, and many more will be deployed over the next few years. The paper will examine "fleet agnostic" steps to follow for deploying charging infrastructure as well as unique considerations and challenges encountered in energizing a school bus fleet.

Keywords : infrastructure, deployment, commercial, fleet, charging

1.1 Introduction

Riding a yellow school bus is a quintessential North American childhood experience and First Student is proud to deliver this experience to more than 5 million children daily. First Student owns and operates a school bus fleet of more than 46,000 buses and is the largest provider of student transportation for school districts across North America. Modern technology, in the form of an electric school bus, has enabled us to make this ride safer and more enjoyable for our young passengers. However, the transition to zero emission buses is not as easy as purchasing the buses and hitting the road. An entire labyrinth of processes and decisions need to be implemented between the purchase of electric buses and making those shiny, new electric school buses capable of running routes and transporting students. These processes lead to what we know as the "deployment of charging infrastructure" which is the backbone of any electric fleet — the physical network that transfers electricity from the utility grid to the vehicles themselves.

1.2 Process Overview

Charging infrastructure deployment for electric school bus fleets is an area that requires special attention to planning and strategy. Each of the steps outlined here, gleaned from First Student's experience in planning, designing and deploying charging infrastructure for its school bus fleet across more than 20 locations in North

America, including the world's largest active electric school bus fleet deployment in the Quebec province of Canada, are "fleet agnostic" and critical to a successful commercial fleet infrastructure deployment. Our large scale Canadian deployment represents a very successful cooperative effort between several diverse entities including First Student, the Government of Quebec, the school bus manufacturer and the utility. There are many firsts associated with this project and unique challenges also including confronting construction in Canadian winters to proudly permanently removing underground fossil fuel tanks to enable electrification infrastructure installation.

First Student's partner school districts are one of the largest recipients of U.S. EPA's Clean School Bus Program rebates, recently announced in October 2022, and we look to follow the same cooperation and collaboration model and the process described below as we begin implementing these projects.

1.2.1 Estimating the fleet's energy needs and charging time periods

The choice of an EV has an impact on the range and charging time. The range of an EV represents the distance it can travel on a single charge. The battery capacity and energy efficiency together determine the charging need of an electric bus. The driving range of the electric school bus and its duty cycle determine the charging pattern.

This interrelationship helps determine how much energy each vehicle will need over the course of an average day (load profile) and the time it will take to deliver that energy (charging window) to help in selecting the equipment needed to "fuel" the vehicles in a timely and cost-effective manner and forecast the cost of electricity.

Energy Used Per Route				
Bus Efficiency (kWh/mi)	x	Route Distance (miles)	=	Energy (kWh)
1.5		50		75

Charger Power Needs				
Energy (kWh)	/	Dwell Time (hours)	=	Power (kW)
75		3		25

Energy per Charging Session				
Power (kW)	x	Dwell Time (hours)	=	Energy (kWh)
25		3		75

Figure 1: Sample Calculations Done During a Route Assessment and Charging Analysis[1]

To go electric, First Student first conducts a school district route assessment. In order to determine if a route is a good candidate for electrification, a multitude of factors need to be considered including temperature, weather, elevation, terrain, and the number of daily runs as these all directly impact the mileage range for the bus's battery. First student examines charging capacity, available downtime, weight restricted roads/bridges, vehicle configuration and electricity cost during the analysis as well. This data is then analyzed to determine which routes are the most suitable for electric school buses and the optimal battery size. A typical bus can travel approximately 0.67 miles on a kilowatt hour of energy or, put another way, consumes about 1.5 kilowatt-hours of energy for every mile traveled (in fair weather). If a typical bus travels a daily route length of 100 miles, it would require approximately 150 kilowatt-hours to travel that distance. This daily energy need must be recouped during the vehicle's daily dwell period, such as when it's parked overnight[2].

After determining the optimal battery electric bus, a fleet must decide which charging technology is best for their application. The route range, duty cycle of the school bus, dwell times and any special considerations, eg., early dismissals in inclement weather, are then evaluated to determine the type (Level 2 – AC or Level 3 DC fast charger) and power of charger required (in kW) to electrify that route.

1.2.2 Utility coordination

An early and sustained coordination with the utility holds the key to a successful electrification project and will help determine the capacity to power the electric vehicles, prepare the electrical infrastructure for the increased load and forecast costs based on electricity pricing tiers and demand charges.

To energize a site, the local utility will need to know the new load that the project will add to the grid, where the new chargers will be installed and the current facility power infrastructure. The additional load is determined based on how many chargers are needed and the charging power (in kW) of each. The utility will then conduct a load study to determine:

- Whether the grid can support the new higher load,
- Whether the power distribution infrastructure needs to be/can be upgraded,
- Whether the site would require a new transformer, and
- What should be the transformer capacity

Further, utility discussions will help determine the different tariffs that impact the cost of charging commercial fleets including applicable demand charges, time-of-use charges or tiered rates. A "managed" charging routine (or charging electric school buses during off-peak hours to stay under a power ceiling) helps avoid overloading equipment and consequently mitigating demand charges. It is critical to understand the different utility tariffs and incorporate them into the electrification infrastructure plan early on since "unmanaged" charging can result in a serious negative financial impact for the fleet electrification project due to significant electricity costs.

Finally, a discussion needs to be had with the utility on available infrastructure upgrade or financial support through make-ready programs and incentives or rebates. Amidst the surge in electric vehicles, utilities are supporting an increasingly wide range of electrification efforts, including investments in vehicles and charging infrastructure. Grant/rebate support from utilities is critical in moderating the cost of this technology. On an electrification project, if there is an opportunity to "utility shop" by moving the project location to a utility's territory that offers better incentives/make-ready programs, assuming all other parameters being equal, then that option should definitely be pursued. An end-to-end system approach in utility rebate programs that include support for buses, EVSE, make-ready infrastructure upgrades both in front of and behind the meter, as well as operational, training, and other administrative rebates will help put this technology safely and effectively into service. Several large utilities have already established medium and heavy duty vehicle incentive programs while new programs are being designed and filed progressively with utility commissions across the country to support fleet electrification.

1.2.3 Site feasibility and charging equipment options

This includes developing charging station configurations that work with the site specifications including a facility's existing space, that support current and future operations, maximize equipment lifecycles control costs and provide for future expansion of EV units.

In order to maximize the return on investments in charging infrastructure, it is essential to conduct a site assessment and determine upfront any major constraints that would prevent electrification of the site. For example, a site on a flood plain might require extensive investments in infrastructure to safeguard assets and ensure safe, uninterrupted operations. Similarly a site without any existing power or maintenance infrastructure (eg., a bare field) would be more challenging and costly to electrify than a depot that already includes these.

A decision-making exercise to identify potential charger locations includes[1]:

- Consideration for best sites
  - Availability of existing parking,
  - Availability of electric panels with spare breakers,
  - Chargers can be placed close to panels,
  - Requires limited trenching
- Installation costs
  - lower with shorter distance and minimal trenching,
  - higher with longer distances, trenching or boring, and more equipment

1.2.4 Project design

This step involves translating all the project requirements into a coherent and custom installation design and construction drawings set for each location that can be used for communicating the design to stakeholders and soliciting construction bids from third party contractors. The design process results in a:

- Site plan outlining the most cost effective and efficient layout of the different components of the charging infrastructure:
  - Power source, whether it be from a new transformer or existing panel
  - Electrical switchgear
  - Placement of chargers
  - Bus Parking
- Electrical plan that describes the details and specifications of electric supply from the power source to the electrical switchgear to the chargers

The site plan helps inform and educate stakeholders about the overall layout of the project and accordingly plan site improvements if required. An accurate electrical plan ensures that all power systems will run safely and efficiently, and that the facility complies with all relevant code regulations.

These drawings are then used for an request-for-bid (RFP) process to obtain construction bids. The greater the clarity in the design process, the less the confusion will be during construction enabling the charging infrastructure installation to be completed in a timely manner.

For its school bus deployments, First Student incorporates its proprietary and customizable *First Group's Mobile Design* in all design plans. This EV charging infrastructure design was the first of its kind, above ground, no trenching, construction model. This novel design provides significant cost savings while offering maximum flexibility in space and parking configurations.

1.2.5 Permitting

Many a fleet electrification project has climbed the ladder in the hopes of success only to be stuck at this penultimate level. The permitting process ensures that the charging infrastructure design meets all local and state codes and regulations. The key player in this process is the Authority Having Jurisdiction (AHJ), who is responsible for enforcing these codes and regulations. The AHJ is typically a government agency or official, such as a building inspector, fire marshal, or electrical inspector. They are responsible for reviewing and approving plans for charging infrastructure installation, as well as inspecting the work during and after construction to ensure compliance.

AHJ requirements can vary depending on location; while some states and municipalities may have relatively straightforward permitting processes, others may have more complex requirements or stricter codes to follow. In some states, AHJ review times can take upto a year. Similar to utility coordination, an early reaching out to AHJs will help determine any red flags and plan for mitigation or resolution of identified obstacles for projects to proceed towards construction in a timely and cost-effective manner. Early interaction with AHJ helps reduce permitting timelines by 20% on average. It also helps reduce drawing package resubmission due to needing to understand the local and regional code requirements.

1.2.6 Construction

The final stage of a commercial fleet infrastructure deployment is also the most anticipated when the plans and designs for energizing the vehicles and subsequent operations begin to take physical shape. An ironed out contract with a contractor (if a third-party will implement construction) with clear and complete understanding of roles and responsibilities, construction tasks and pricing, will go a long way in the smooth delivery of the project. Another critical part of this process is equipment commissioning, operational handoff, and developing preventative, corrective, and routine maintenance. In the United States, all OSHA standards for construction should be followed with regular facility walk-throughs and follow-ups with the contractor, and record keeping of all permits, inspections and approvals.

1.3 School Bus Fleet Considerations

While the above exercise must be followed regardless of a fleet's specific needs, there are unique characteristics applicable to a school bus fleet that will impact the charging needs and must be taken into consideration when planning for deploying infrastructure.

1.3.1 Dwell Times

Owing to midday dwell times school buses are best suited for electrification and have the least impact on the grid compared to other medium and heavy duty vehicles since school buses have the ability to be recharged between the AM and PM runs. Most bus schedules have a long overnight dwell period that is great for recharging the vehicle's batteries. However, many school buses are also be able to charge in the middle of the day to support longer routes or evening activities. The middle of the day and early morning hours also provide an opportunity to mitigate demand charges by avoiding adding to the building peak load. The ability to shift this charging load throughout the day is dependent on the recharge time of the vehicle relative to the dwell period. For example, it would take 7.8 hours for a 19.2 kilowatt AC level two charger to provide a battery electric bus with about 150 kilowatt-hours of energy[2]. A DC fast charger (DCFC) would obviously lower that recharge time.

1.3.2 Grid resiliency and V2G application

School buses provide an excellent use case for supporting grid resiliency and transition to renewable energy when paired with vehicle-to-grid (V2G) technology. EVs, by virtue of being energy storage units, can potentially provide bidirectional flow of power using V2G functionality. Electric school buses when not running school bus or charter routes, especially during summer and other school breaks, largely sit idle allowing their batteries to be available as a source of energy storage. If every one of First Student's 46,000 diesel-powered buses were to be replaced with a V2G-capable electric bus of the same type, this would create a total of 7.4 gigawatt-hours of additional stored energy capacity — enough to power more than 33,000 average American homes for a week[3].

1.4 Challenges Encountered

As an early entrant into the fleet electrification arena and by virtue of its numerous electric deployments, First Student has encountered a variety of challenges on the journey towards fleet electrification and specifically during fleet infrastructure deployment.

1.4.1 Cost

This new technology presents its own unique set of challenges, primary among them being cost. One of the barriers to electrification is securing grants, rebates, and/or utility incentives to offset the initial high capital investment in electric buses and infrastructure.

Several public sector grants at the federal, state and local level are available to fund school bus fleet electrification. In the United States, with funding from the Bipartisan Infrastructure Law, US EPA's Clean School Bus Program will provide $5 billion through 2027 for deploying zero emission and other clean school bus fleets. Prior to this program, federal ARP (American Rescue Plan) grants have been utilized for incorporating electric buses in school bus fleets. A number of states have distributed Volkswagen Environmental Mitigation Trust funds and US EPA's Diesel Emissions Reduction Act (DERA) grant funds and rebates for electric and other green bus fleet deployments. In Canada, the Canada Infrastructure Bank has established a C$2.75 Billion Zero Emission Transit Fund to provide funding for similar projects to replace gas/diesel-powered buses with zero emission vehicles. There are also state and local programs, typically sponsored by the Air Quality Management or Air Pollution Control Districts, that offer additional funding options.

However, even when secured, piecemeal award of grants with restrictions or lack of utility make ready programs impact the financial viability of projects and deny large fleet operators the ability to achieve economies of scale and consolidation of services for fleet electrification infrastructure deployment.

The timeline for these grant awards can vary from as little as 3 months to as long as 18 months. The long timespan of execution of some of these grants frequently results in increased cost of vehicles, chargers, electrical gear, and construction that are not covered by the original grant award and leave fleet operators scrambling for additional funds.

With all types of grant funding, whether it be public sector grants or utility program grants, the devil is in the details. It is imperative to thoroughly understand the grant terms and conditions, and the percentage award coverage for vehicles and/or chargers and infrastructure extended by the grant. In many cases, the grant may not cover the cost of bringing the total cost of ownership of an electric bus fleet to diesel parity. The financial implications of this must be clearly understood and factored in the decision-making around fleet electrification.

1.4.2 Unfamiliarity or Newness of the Technology

Another barrier to implementing electrification is the newness of the technology and unfamiliarity with the whole process of electrifying a fleet including:

- Range anxiety – school bus fleets are entrusted with a major responsibility of transporting students to and from school and absolutely cannot afford to have stranded pupils due to technical limitations of the battery
- Lack of understanding – stakeholders still have less awareness and understanding of e-mobility
- Access to domain experts to assist with appropriate selection and sizing of vehicle batteries and chargers, coordination with utilities, conducting site assessments and determining power requirements for the site, designing infrastructure, managing construction and deployment, servicing and maintaining EVs etc..

1.4.3 Technology limitations

Current battery technology limits the usable route range that can be accommodated on electric buses. Electric buses also take much longer to “re-fuel”. This can be a challenge for operating school buses on long routes in rural and suburban areas. With current technology, it can be expensive to electrify longer routes since it requires purchasing buses with larger batteries and building infrastructure that can support DC fast chargers (DCFC). DCFC are also more expensive, and the additional costs directly impact the financial viability of each electrification project. In addition to the additional infrastructure cost, DCFC and high demand charging intervals can have a negative impact on electricity costs. Therefore, on all electrification projects, we generally seek to electrify shorter routes first. Notably, for buses with larger batteries, the vehicle design configuration can result in lower passenger capacity which needs to be taken into consideration. While many manufacturers boast battery ranges from 125 miles to 200 miles, these calculations do not consider maximum and minimum state-of-charge and often don’t account for “real world” operating parameters that operators confront. For example, the actual usable range on an electric bus is usually less compared to OEM supplied ranges since they do not take into account regenerative braking, and ancillary loads such as heat and airconditioning.

Another challenge with current battery ranges is that electric school buses are not able to cover long charter trips since those require convenience charging along the way. Currently, this infrastructure is still being built and is not readily available so drivers would need to plan their route so that they can find places to “re-fuel”. Drivers would also have to take into consideration that these buses take longer to “re-fuel” and they would have to account for the time the bus will be parked along the trip. With technology constantly improving and becoming more readily available, there is hope to have access to batteries and infrastructure that could make longer daily routes as well as charter routes electrifiable.

1.4.4 Supply chain crisis impacting the availability of electrical gear

The fleet electrification industry is currently plagued by delays in procurement of electrical switchgear, chargers and EVs due to chip shortages, battery shortages, and competition for sourcing the same components across multiple industries. These delays often result in long project delivery timelines and escalated costs. Building contingency timelines into the project plans and collaborating with multiple vendors can assist with mitigating these interruptions. One approach has been to order electrical gear early in the process in order to reduce timing impacts. However, some grants, notably those from EPA, do not allow for reimbursement for equipment ordered prior to the funding award. Therefore, the operator can be at risk for ordering equipment prior to funding notification.

1.4.5 Contingencies

Beyond some of the traditional barriers to electrification including cost, unfamiliarity or newness of the technology, an additional unique challenge for electric school bus operations include contingencies, such as early school dismissals due to snow etc., that can throw the charging cycle into a disarray and require spare fossil fuel buses for operations, or worse leave children stranded at schools, if not planned for properly. Solutions to manage these scenarios would typically require higher upfront investments in larger capacity, fast charging equipment (DCFCs) and associated infrastructure to support those.

1.5 Conclusion

Change is hard; however, transition to electric and other green technologies is inevitable and is happening all around us. The completion of construction upon testing and commissioning of chargers and receiving the battery electric bus represents the culmination of an intense and complex, yet immensely rewarding, process to deploy electric fleet infrastructure and commencement of realizing the benefits of this clean, sustainable, next generation transportation technology. While there are several challenges to electrify a large commercial fleet and navigating these unchartered waters is daunting at first, this is also a moment of new opportunities for fleet operators like First Student to share the numerous benefits of electrification with our communities, and with our most precious cargo, school children.

Acknowledgements

Lloyd Ickes, Director of Charging, First Student

Ami Parikh, Senior Project Manager, First Student

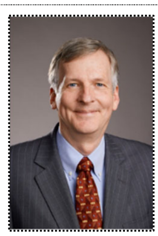
References

[1] U.S. EPA Clean School Bus Webinars, *2022 CSB Rebates Selectees Utility and Infrastructure Planning*, Archived at https://www.epa.gov/cleanschoolbus/events-related-clean-school-bus-program, February 9, 2023

[2] Alternative Fuels Data Center at the U.S. Department of Energy, *Flipping the Switch on Electric School Buses: Charging Infrastructure: Module 1*, Archived at https://afdc.energy.gov/vehicles/electric_school_buses_p4_m1.html, 2022

[3] James Horrox, Matt Casale, Sarak Nick at the The Frontier Group, *Electric School Buses and the Grid,* Archived at https://frontiergroup.org/resources/electric-school-buses-and-grid/, March 14, 2022

Presenter Biography



Kevin L. Matthews is the Head of Electrification at First Student and is responsible for the strategy that will drive the development and deployment of all electrification initiatives and technologies. First Student is the largest operator of school buses in North America with over 46,000 units in its fleet. Kevin has worked in the environment sector for more than 30 years. He has served as the managing director of the sustainability sector at National Strategies, LLC, as well as served as the co-project director of the Clinton Global Initiative EV School Bus project, that demonstrated Total Cost of Ownership of electric units could reach parity with fossil fuel school buses.